

How Long Can the Hubble Space Telescope Operate Reliably?

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Outline

- **Introduction**
- **Service Missions**
- **Total Dose Analysis and Results**
- **Other Potential Failure Mechanisms**
- **Summary**



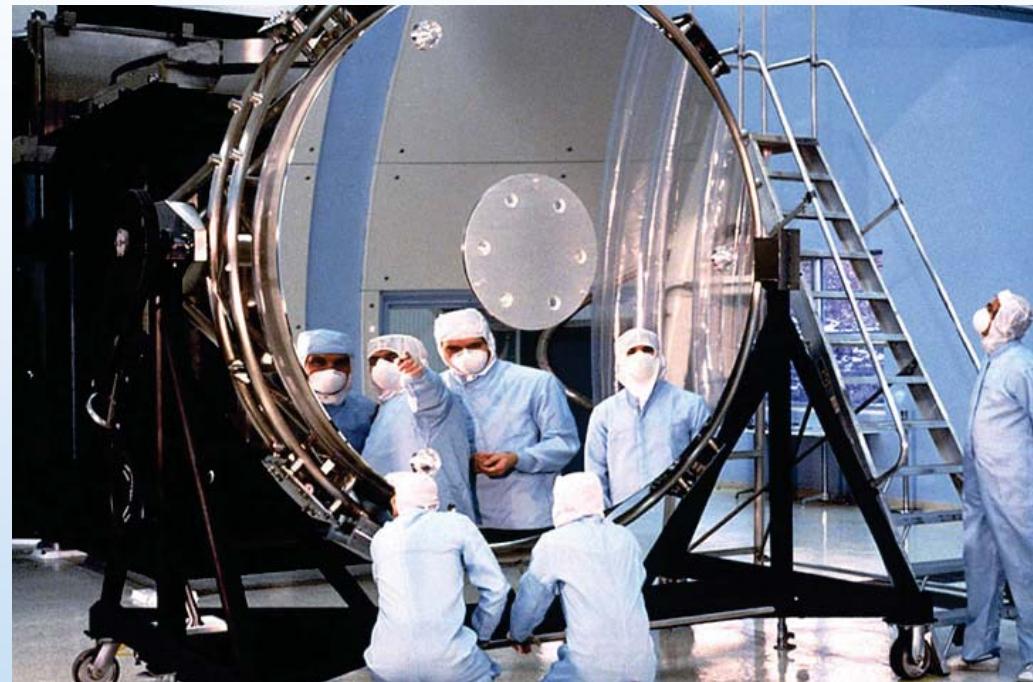
Credit: <http://www.spacetelescope.org>



Introduction

- **Hubble Space Telescope (HST) deployed from Discovery April 25, 1990**
 - Low Earth Orbit, 590 km altitude, 28° inclination
 - First telescope designed to be serviced in space
- **Advantages in space:**
 - No atmospheric distortions
 - Little background light
 - Portions of ultraviolet and infrared spectra seen, not observable with Earth-based telescopes

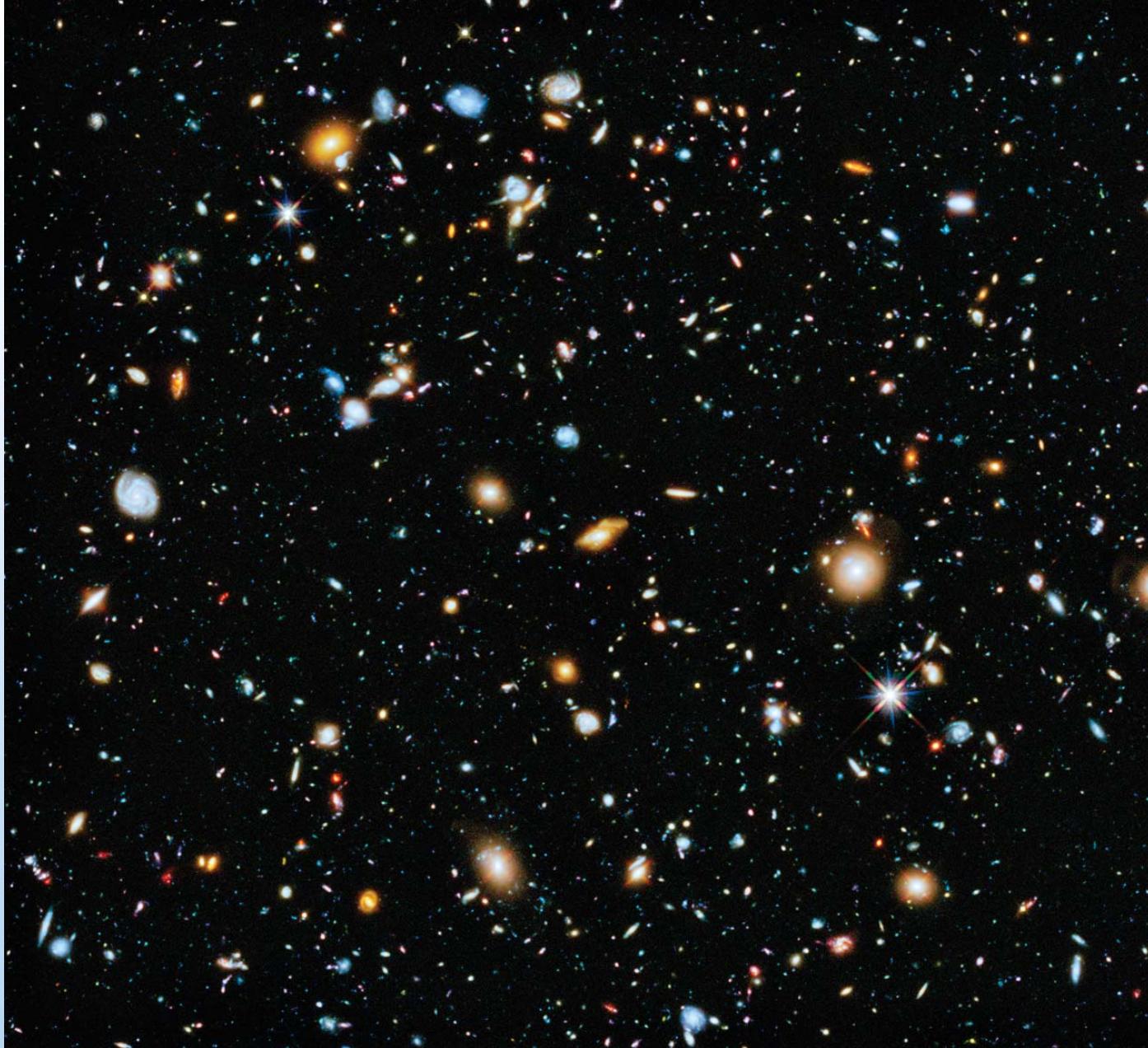
2.4 meter diameter primary mirror



Credit: <http://hubblesite.org/>



The Universe, Looking Back in Time



Credit: <http://hubblesite.org/>

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Service Mission 1 Corrective Optics

Galaxy M100, Before



Galaxy M100, After



Credit: <http://hubblesite.org/>



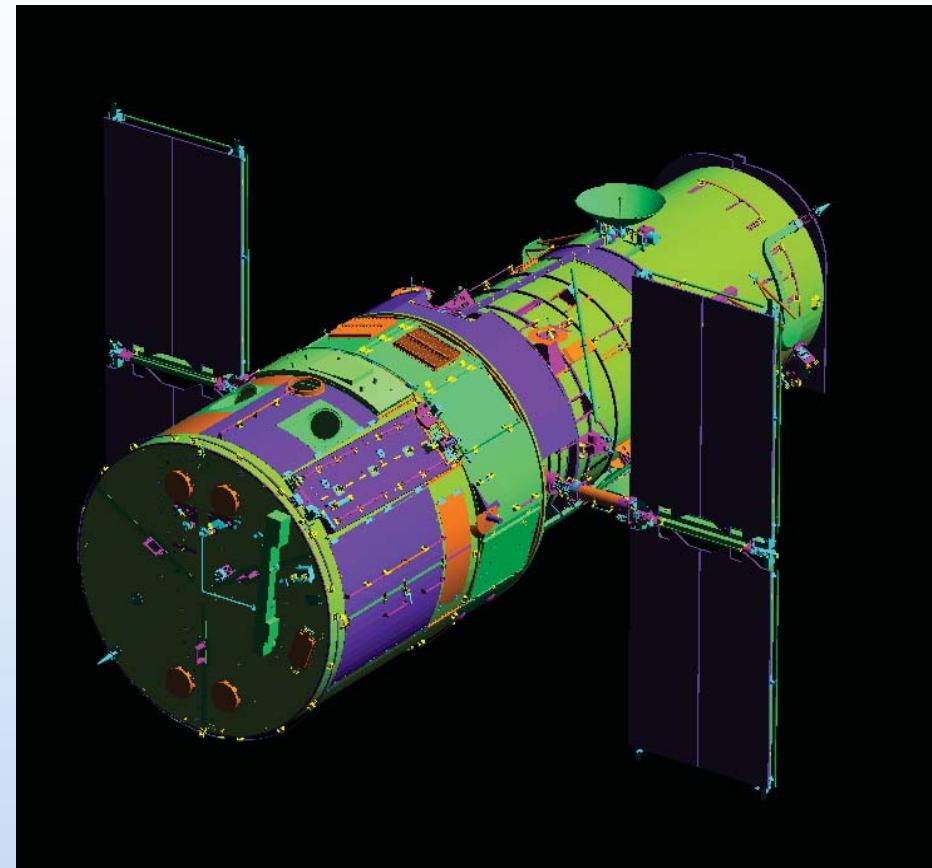
Desired HST Lifetime

- Fifth and final HST servicing mission occurred in May 2009.
 - Planning has been for one mission every 4 – 5 years
- James Webb Space Telescope (JWST), the successor to HST, launches no sooner than 2018.
- Preferable that HST and JWST operate simultaneously for at least 1 – 2 years.
- Can HST continue reliable science operations until then?
- Main radiation concern is a hard failure due to total ionizing or non-ionizing dose.
 - HST in orbit for 24 years



Total Dose Analysis

- Used NOVICE code for 3-D ray trace and Monte Carlo radiation transport.
 - Lockheed Martin spacecraft CAD model imported
 - Extensive review and implementation of subsystem and instrument dimensions, mass and placement
- Used Boeing TPM-1 for trapped protons
 - True solar cycle dependence
 - Service missions add another level of complexity to analysis
- Used AE-8 for trapped electrons.
 - Results insensitive to electron model

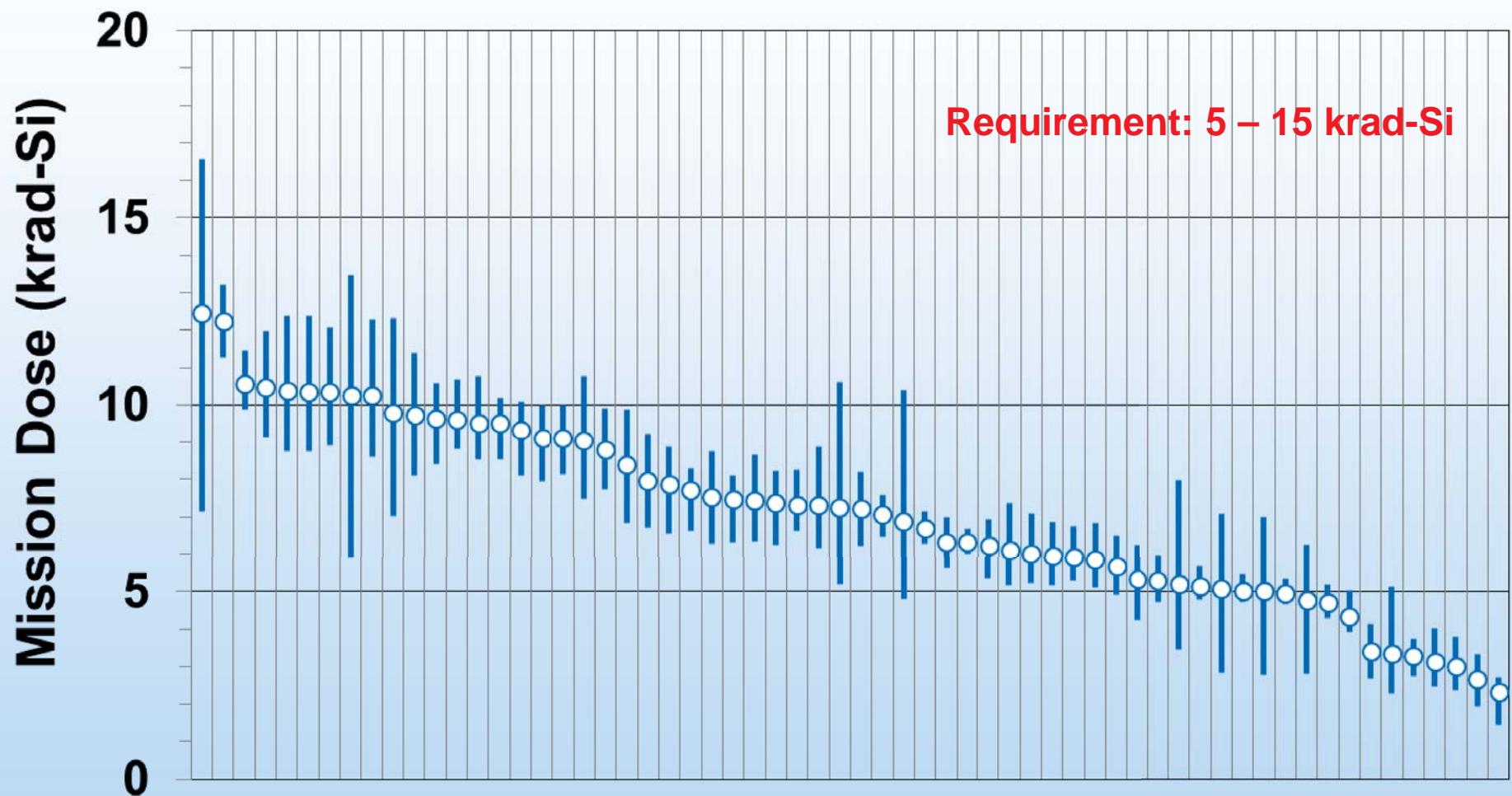


HST NOVICE Radiation Model



Expected Mission Dose in 2020

62 Subsystems / Instruments





Other Potential Failure Mechanisms

- **Gyroscopes**
 - 5 currently functional; 3 required
- **Fine Guidance Sensors**
 - 3 currently functional (1 barely); 2 required
- **Batteries**
 - 6 battery system expected to last ~ 10 years
 - All 6 replaced during 2009 servicing mission
- **Avionics System Reliability**
 - Predictive model shows 50% failure possibility in 2018, but is known to be conservative
- **Loss of Science Instruments**
 - Designed for 5 years but typically last longer
 - 2 installed in 2009 with full redundancy
 - 2 repaired in 2009, but now lack full redundancy



Summary

- HST has been in orbit for about 24 years.
- A key goal is to keep science operations going for a year or two after JWST is launched.
- As a result of HST's longevity, total dose failures are an important consideration for continuation of the mission.
 - Just as significant as the other major potential failure modes.



Acronyms

- **HST – Hubble SpaceTelescope**
- **JWST – James Webb Space Telescope**
- **NOVICE – Numerical Optimizations, Visualizations, and Integrations on CAD/CSG Edifices**
- **CAD – Computer Aided Design**
- **CSG – Constructive Solid Geometry**
- **3-D – three-dimensional**
- **TPM-1 – Trapped Proton Model-1**
- **AE-8 – Aerospace Electron Model-8**